LUBRICATION

A Technical Publication Devoted to the Selection and Use of Lubricants

Published Monthly by

The Texas Company, 17 Battery Place, New York City

Vol. XIII July, 1927 No. 7

Change of Address: In reporting change of address kindly give both old and new addresses.

Automotive Engine Lubrication

The Effect of Traffic Conditions and Warm Weather

DEVELOPMENT of automotive transportation since the war has been conspicuous for its leaning towards higher temperatures of engine operation.

From an operating point of view this may be regarded as due to modern traffic and driving conditions; from the mechanical angle, as a result of the trend towards the adoption of engine design involving higher running temperatures.

All this has a decided bearing upon engine lubrication and the determination of the proper grades of oils which will effectively meet these conditions. It will, therefore, be of distinct interest to the motorist to discuss these latter, and the degree to which his own particular mode of driving, or type of engine, may require consideration when he buys his oil for the latter.

Modern traffic imposes a decidedly severe load upon a motor oil. Average speed conditions are higher, traffic regulation is more rigid and the range of travel has become increased to a marked degree. All are conducive to more frequent starting and stopping, and to longer periods of idling, especially when driving through city traffic to any extent.

Increased speed between signals is more and more becoming the practicable solution of the traffic problem from the officer's viewpoint, and the only way to avoid unnecessary congestion from the motorist's.

But the stops are more frequent, and a minute of idling at each, especially on a warm day, will frequently be the cause of an overheated motor, due to the fact that when an engine is idling very few pumps give adequate circulation of cooling water. Nor will speeding up for a few blocks help to alleviate such a condition once begun, even though less heat is developed by the burning of a smaller amount of gasoline during such operation.

And yet, no real detriment can result. Nor should car operation be any more difficult, for engines are designed today to meet such conditions. In fact, by the adoption of certain types of design many engine builders themselves have created a mechanical condition which will result in higher operating temperatures, regardless of driving or traffic requirements. But this must be taken into account when selecting motor oil.

Trend in Engine Design

The trend in modern engine design is towards higher compression; that is, the pressure of the mixture of gas and air in the cylinder of the modern engine just prior to explosion is higher than formerly. This means that there will be more work done for each explosion, and the lubricating film will have to carry a higher pressure momentarily. While for a very short time the temperature in the combustion chamber may be higher than usual, the average temperature is lower due to the fact that more energy is used up in useful work and less is passed out of the exhaust and to the cooling water.

The ultimate load, of course, must be borne by whatever motor oil is used to lubricate the engine bearings, cylinder walls, valve stems, timing gears and such other parts as may be served by the lubricating system according to the design of the latter and the method of lubrication employed.

There are a number of angles from which such an oil should be viewed when it is to be selected for service in the modern automotive engine, viz.:

The Viscosity
The Carbon Residue Content
The Flash and Fire Tests, and
Crankcase Dilution.

VISCOSITY

It is a characteristic of most liquids to become thinner or more fluid when subjected to an increase in temperature. For the information of the motorist, in the petroleum industry, this is termed reduction in viscosity. It will be of further advantage to the layman to know that viscosity is regarded as a measure of the relative fluidity of an oil at some definite temperature of observation. In brief, it is that inherent property by virtue of which the flow of certain liquids will be retarded. It is possessed by all lubricating oils to a varying degree, depending on their source, range of distillation, and extent of refining or blending.

More technically speaking, viscosity could also be regarded as a measure of the resistance which the particles or molecules of an oil will offer to one another as they come past each other in circulation through the lubricating system.

Modern Engine Conditions Require Higher Viscosity

It is perfectly evident, therefore, that our modern conditions of higher automotive engine temperatures will lead to an increase in the degree of fluidity of the motor oil which is used for lubrication. Especially will this be true in warm weather, when the amount of external cooling will be appreciably lower than in cold weather, or under lower atmospheric temperature conditions.

This will call for the utmost care in the selection of the proper grade of motor oil for warm weather operation. Haphazard choice without adequate knowledge of the approximate "operating viscosity" of the proposed oil may be the forerunner of too great a variation in the fluidity of the oil in service, with oftentimes ineffectual lubrication of certain of the wearing parts of the engine. The ultimate occurrence of scored or burned out bearings, of abnormal wear on cylinder walls, and an excess of oil pumping past the piston rings, will all lead to increased cost in car maintenance and a natural decrease in power output or engine efficiency.

The Motorist Must Be Informed

In view of the importance of the viscosity characteristic, and the attention which should be given to it by the motorist when buying his motor oil, he should be informed both as to the method of test and the range limitations for the several accepted grades of motor oils. In other words, he should know the approximate range of viscosity involved when he buys a grade of "heavy" motor oil, for example, regardless of who it is manufactured by. Furthermore, he should know what the oil industry means by stating that a certain "heavy" motor oil has a viscosity of, say, 500 seconds Saybolt at 100° F.

In this way he can frequently detect any attempt to "put over" improperly refined oils which may be way out of line in regard to the "operating viscosity" requirements of his particular engine.

A Typical Example

For example, say he should call for a quart of motor oil heavy of "X" brand. In some cases the colors of certain motor oils are so nearly alike as to be deceptive. So the dealer in question has had a chance to stock up with a grade of "Y" oil at a low price and of a comparatively low viscosity. This product he foists on the unsuspecting motorist who called for "X" motor oil.

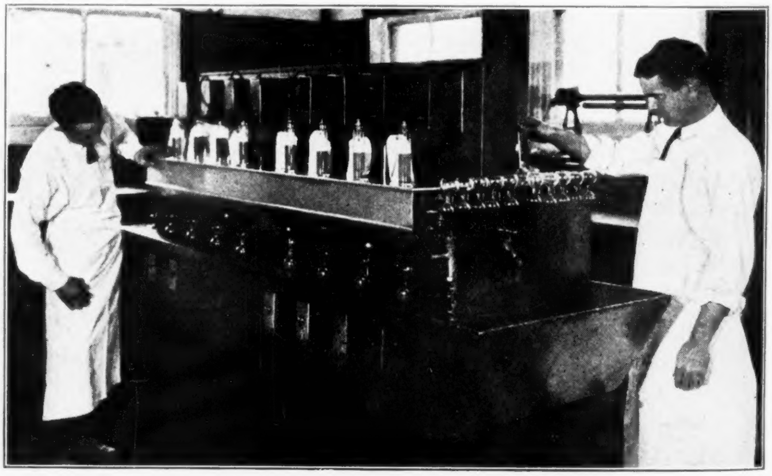


Fig. 1.—Illustrating the apparatus involved in the testing of lubricating oils for viscosity under the Saybolt Universal method. Every precaution is observed to maintain the temperature of test as constant as possible.

But if the latter is posted on viscosity, he will usually detect a difference the moment "Y" oil starts to pour into his crankcase. He should then call the dealer, stop the addition of any more oil, and immediately ask for an approxi-

mate viscosity comparison with a standard sealed sample bottle of motor oil heavy of "X" brand.

This is an easy test to make, by simply filling a bottle of approximately the same capacity with the suspected oil, corking the latter, and inverting both simultaneously, watching the rise of bubbles in each. The more rapidly these latter rise, the lower the viscosity. Hence, if the bubble in the sample of suspected oil rises more rapidly than that in the standard sealed sample of motor oil heavy of "X" brand, the viscosity of the former is probably too low and usage of such an oil might subsequently cause trouble due to insufficient lubrication.

Such a comparison test affords an ideal opportunity for checking up on any dealer who may be imposing on both the motoring public and the reputable oil company for whose product he is attempting to sell inferior substitutes.

Meaning of Viscosity

As a result the motorist should know that when the statement is made that an oil has a viscosity of let us say 500 seconds Saybolt at 100° F. this means that the body or relative fluidity of the oil in question is such that, at a uniform temperature of 100° F. it will take 60 cubic centimeters of this oil 500 seconds to flow through the orifice of the standard Saybolt viscosimeter. Fig. 1 shows such a test being made in the Laboratory.

In other words, viscosity is measured by observing the time required for a predetermined quantity of oil to flow through an orifice of standard size under standard temperature conditions. The Saybolt universal viscosimeter has been adopted for this purpose by the American Society for Testing Materials.

Temperature of Test

It is evident that any temperature could be selected for such a test. The petroleum industry, however, usually regards 100° F. as standard when dealing with motor oils of normal fluidity, that is, products up to about 900 seconds viscosity. For heavier products, such as certain motor-bus or airplane engine oils, 210° F. is the usual standard temperature. The advantage of raising the temperature of test with such products is to decrease the time element involved and expedite the actual procedure of testing.

Value of the Viscosity-Temperature Chart

In connection with this matter of viscosity, it will be of interest to the motorist to study the viscosity-temperature conversion chart on the inside front cover, and to note the curve for

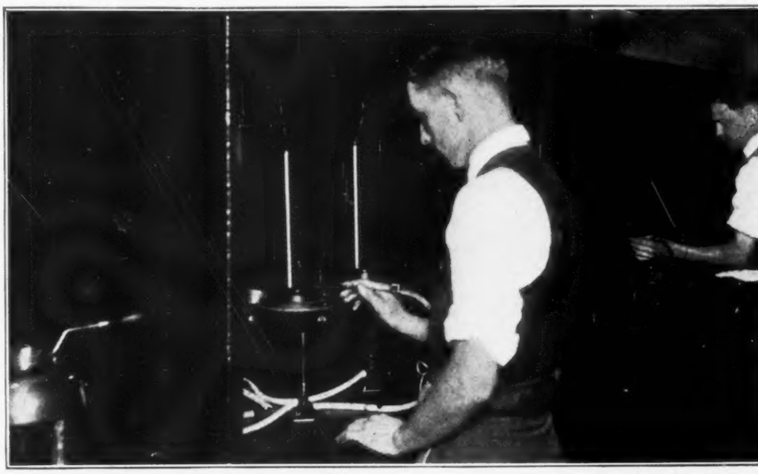


Fig. 2.—Testing motor oils for flash point. In the foreground is shown method of test involving the Cleveland open cup equipment. The utmost care must be observed in order to work as free from air drafts as possible.

a typical grade of motor oil refined to meet the requirements of warm weather operation.

With such a chart it is possible to estimate very closely the approximate operating viscosity of any particular grade of oil up to 300° F., or to note what the viscosity would probably be at atmospheric temperature down to zero. Of course, this latter only applies to oils of zero pour test.

It is invaluable to the motorist to be able to study motor oils from this point of view, for it will be bound to lead to a more intelligent selection of an oil which will be capable of assuring effective lubrication by virtue of its proper "operating viscosity" at the mean operating temperature of his particular engine.

In addition, it is important to state that the motorist should guard against any hasty impression that motor oils of lighter color will have less body than comparative products which may be darker or more opaque. The viscosity test is the sole criterion and should be used as the only comparison when body is in question.

Color has absolutely no bearing upon viscosity, though it is a very vital factor as an indicator of lubricating ability, for it is a direct guide as to the probable carbon residue content of any oil.

CARBON RESIDUE A DETRIMENT

In the selection of a suitable grade of motor oil for warm weather service in practically any automotive engine it is decidedly advisable for

the motorist to have an understanding of the detrimental effects which may result from the use of a lubricant which shows a high percentage of carbon residue.

Broadly speaking carbon can never be eliminated. It is an essential component of any petroleum lubricating oil, and therefore must pass through every engine.

It is only a detriment, however, in the form of soot or deposits of carbonaceous tarry matter. These may, of course, have a very decided effect upon the operation of the engine and the amount of power developed, according to the extent to which carbon deposits are formed on the spark plugs, pistons, cylinder heads, around the rings, on valves and valve seats, and in the crankcase or oil sump.

Factors Governing Carbon Residue Content

Of course, the amount of ultimate carbon will all depend upon the degree of heat present, the extent of refinement of the lubricant, and the base of the crude from which it is made. From particular types of crude, for example, distillates can be produced which will show an almost negligible carbon residue, 0.05 being a fair idea of the amount to be expected.

The use of residual oils, however, for the purpose of blending and increasing the viscosity may easily raise the carbon residue percentage in the ultimate product to above one per cent. Such oils can be distinguished by their dark green color.

As a general rule the carbon resulting from blended oils of paraffine base residuals will be harder and of a more abrasive nature than carbon from lubricants having equal viscosity but which are wholly of a distilled nature. Where hard carbon remains in the combustion chamber or on piston heads "knocking" and lack of power will be the noticeable consequences.

From an efficiency point of view these are decided detriments. In addition, however, where these residual oils are used there will also be the potential danger of scored cylinders and worn rings due to the abrasive nature of the resultant carbon, for a certain amount of this latter will always be developed on the upper part of the cylinder walls to be retained by any lubricant that may be present, and ultimately carried past the piston rings by diluent or unburned portions of the gasoline.

Hard abrasive carbon does its greatest damage at this stage as a promoter of wear in so passing through the engine.

Of course all the carbonaceous deposits in the average automotive engine do not entirely come from the lubricating oil. Operating in such a manner as to involve incomplete combustion of the gasoline or an abnormal amount of dilution of the lubricating oil will also tend to increase the amount of carbon formation.

Effect on "Operating Viscosity"

Relative to this question of dilution it is advisable to remember that the lower the "operating viscosity" of the lubricant, or the thinner the film on the cylinder walls, the more readily will it fill the crankcase with a fine lubricating mist. This may, though not always, (depending upon the design of the engine) increase the possibility of pumping or forcing of the lubricating film up into the combustion chamber where it will be ultimately burned. The direct result is the development of more or less carbon deposits therein.

The intensity of these latter will, of course, depend upon the residual carbon content of the oil. Where the latter burns cleanly the amount of such deposits will be relatively small. Furthermore, if the oil is properly refined from a crude of suitable base, and adapted to the purpose in hand, such carbonaceous matter will be soft in appearance, low in quantity and comparatively easy to remove.

Relation to Dilution

Over extended periods of operation, however, carbon deposits whatever their nature will be bound to increase. Furthermore, where pumping or forcing of too great an amount of lubricating oil into the combustion chamber occurs, the ultimate oil consumption will be higher, with a reduction in the mileage developed per gallon.

In addition, dilution may involve the possibility of a certain amount of loss of compression due to impairment of the piston seal when the viscosity of the oil is so reduced that the lubricating film is comparatively readily wiped off by the piston rings.

Essentials of Correct Operation

So it is important to operate an engine at all times with a view to reducing both the formation of carbon and the occurrence of crankcase dilution as much as possible. To bring this about and promote the efficiency of operation, and extend the life of the engine bearings and cylinders, certain precautions must be observed. In brief, they are:

1. Run on as lean a mixture as possible in conformation with atmospheric temperature and the load to be handled.
2. Do not flood the carburetor.
3. Prime as little as possible.
4. In cold weather be sure that the hot air intake pipe attachment is in proper position to enable the admission of heated air to the carburetor.

5. Keep the engine warm, especially in cold weather.

6. When necessary to use the choke, let the sound of the engine be the guide. As soon as one or two revolutions are made and the engine indicates steady running, push the choke back in or turn the handle to "hot" position according to the make of the car.

Fig. 3.—Details of the apparatus employed for the determination of carbon residue content in a motor oil. This is the method approved by the American Society for Testing Materials and the Society of Automotive Engineers. Note the crucibles contained within each other as mentioned in the text. The oil to be tested is contained in the inner crucible.

7. Never flush the crankcase with kerosene alone except where arrangement of the oiling system permits complete drainage of the case. Always give it a final slushing with light motor oil. Kerosene is helpful in removing heavier particles of adhesive sludge.

8. Change the oil at frequent intervals. The cost of oil is negligible in comparison with the cost of lay-up and repairs on the average motor vehicle.

Incomplete Combustion

Incomplete combustion is regarded by many authorities as an important source of carbon difficulties. In general it will be the result of faulty ignition, or carelessness or ignorance in regard to carburetor adjustments, the resultant mixture of gasoline and air being unsuited to the power requirements and engine conditions involved.

Carburetors, of course, should not be tampered with too frequently, nor by any one inexperienced as to their design and construction. They should, however, receive attention commensurate with atmospheric temperature conditions. Normally they are adjusted when hot in order to obtain the best fuel economy, and to prevent dilution as much as possible.

Part Played by the Lubricating Oil

The use of too much lubricating oil is another frequent reason for abnormal carbon deposits. Theoretically a very small amount of oil is necessary to maintain the requisite lubricating film on the cylinder walls and serve the respective bearings; actually, however, a considerable excess of oil will be used.

Provided the rings give the proper degree of seal and the cylinder walls are not abnormally worn, but little of this oil should pass to the combustion chamber. Either burning oil or incomplete combustion will be indicated by the smoky appearance of the exhaust.

Free Carbon

A certain amount of free carbon will also be present in practically every crankcase after the lubricant has been in service a short time. In part this is caused by breaking down or partial decomposition of the lubricating oil; and in part, as stated, to incomplete combustion of the fuel. Normally such carbon is frequently carried into the crankcase, as has already been stated, by the diluent portions of the fuel, or the lubricating film on the cylinder walls. Carbon in the crankcase is detrimental in that it not only promotes the formation of crankcase sludge, but as well is influential in producing emulsions.

External Foreign Matter Also a Detriment.

Dirt, grit and road dust must also be considered in a discussion of crankcase deposits. Foreign matter of this nature is perhaps the most detrimental to any engine. Not only does it tend to become a part of any real carbon deposit above the piston, but also when present in the lubricating system there will always be a possibility of the bearings being scored.

Manner of Entry

Dirt, grit and other abrasive particles may find their way into the lubricating system in a number of ways. The oil may originally have contained such foreign matter if it has not been carefully refined; the oil storage or measuring containers may have been dirty; the operator may have neglected to replace the cap on the filling pipe, or have accidentally brushed some dirt from the hood or engine into this pipe or his filling measure; or road dust, etc., may

have been taken into the engine with the air, either by way of the carburetor or the crankcase breather device.

Lubrication the Ultimate Protection

Just as long as the lubricating film is sufficiently thick to prevent any such foreign matter from coming simultaneously into actual contact with both bearing surfaces, little or no damage will result, and the possibility of scoring will be negligible. But as soon as the viscosity of the lubricant becomes so lowered by dilution that the film thickness is materially decreased, it will no longer serve as a covering medium for abrasive foreign matter. In other words, such particles of grit, dust or dirt as may gain entry to the bearings will be carried through them in actual contact between the wearing surfaces, and scoring will be bound to occur.

Methods of Test for Carbon Residue

The A. S. T. M. Method

The determination of the carbon residue content of any proposed lubricant can be accurately made by the method adopted by the American Society for Testing Materials.

In brief this involves the external heating of a measured quantity of the oil within a suitable arrangement of crucibles until all vapors have been driven off—that is, until complete distillation has been accomplished. The residue within the innermost porcelain crucible will be the carbon residue content of the original sample of oil. By careful weighing it can be expressed on a percentage basis in relation to the oil under test.

The Hot Plate Test

A more relative means of determining the extent to which a lubricant will develop carbon residue involves the hot plate test, so familiar to the motorist. As a rule it is practicable as a qualitative test only.

This involves the use of a simple domestic type of electrically heated hot plate. By means of a suitable voltage-varying plug the ultimate temperature to which such a plate will be heated can be controlled. This is of especial value where lubricants to meet varying high temperature conditions are concerned.

The method of test is to bring such a plate to the requisite temperature, and then deposit a drop of the proposed oil thereupon. The resultant smudge or carbon residue which will remain after vaporization of the lighter more volatile fractions which compose the lubricant, will indicate the relative degree to which such a product will probably develop carbonaceous deposits in actual service.

FLASH AND FIRE TESTS

Exaggerated importance is frequently attached to the flash and fire tests of certain motor oils. In consequence, it will be advisable to discuss these characteristics in detail and note their actual significance for the benefit of the motorist.

Relation to Operating Temperatures

There is a direct tie-up between flash and fire tests and engine crankcase and cylinder wall operating temperatures. In other words, the oil must not only be capable of functioning without an undue amount of vaporization at the former but it must also burn cleanly at those higher temperatures of the cylinder walls where lubrication ceases to be a function on the occurrence of the explosion stroke.

Average Crankcase Temperature

The crankcase temperature can normally be regarded as the temperature of the engine bearings; a fair average would be in the neighborhood of 130° F. As a result 130° F. is often chosen as a standard temperature for the determination of viscosity, as indicated in the temperature-viscosity conversion chart.

Cylinder Wall Temperatures

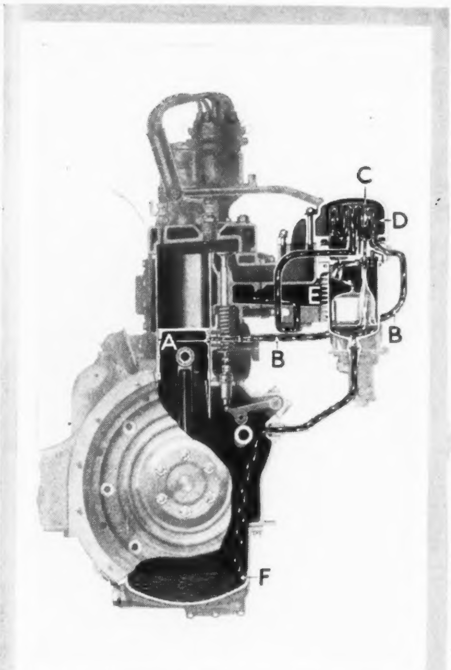
Cylinder wall temperatures, however, will be considerably higher, the mean average being in the neighborhood of 250° F. at the upper parts of the cylinders. Of course, temperatures up to 300° F. may be encountered, but the actual matter of lubrication at such points becomes an almost negligible factor.

In fact, no motor oil can withstand the heat of explosion in the combustion chamber, or on the uppermost part of the piston itself; nor is lubrication actually a necessity here, due, to the customary practice of locating the top piston rings somewhat below the top of the pistons. So, regardless of the flash point, any motor oil which reaches the upper parts of the cylinder walls must burn. **The ideal oil is that which burns as clean as possible, i.e., leaving the least amount of carbon residue.**

The flash and fire points are, therefore, but interesting talking points to a certain type of motorist who is uninformed as to the actual temperature range in his engine.

Indicative of Carbon Content

On the other hand flash and fire are frequently indicative of the probable carbon residue content of a motor oil, and here is their real significance to the motorist. In other words, with oils of approximately the same viscosity the higher the flash and fire points the higher can we expect the carbon residue content to be.

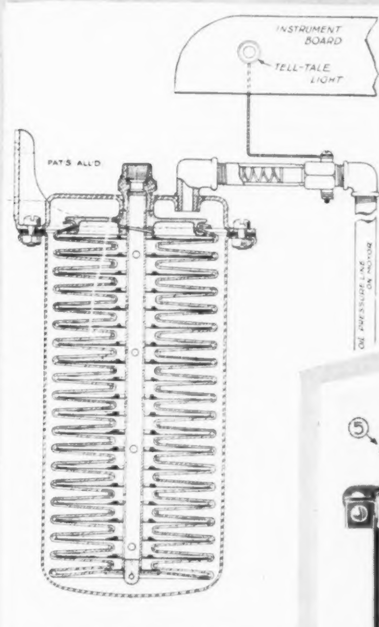


Courtesy of Skinner Automotive Device Co., Inc.

Fig. 4—Details of an engine showing means whereby crankcase oil is cleared of dilution. At A, unburned gasoline, water vapor and surplus oil is drawn from lower piston ring groove. These fluids pass via B to be heated by exhaust gases D in compartment C. Volatile constituents pass thence to manifold to be burned. Reconditioned oil passes via passage E to lower chamber of rectifier and thence back to the crankcase F.

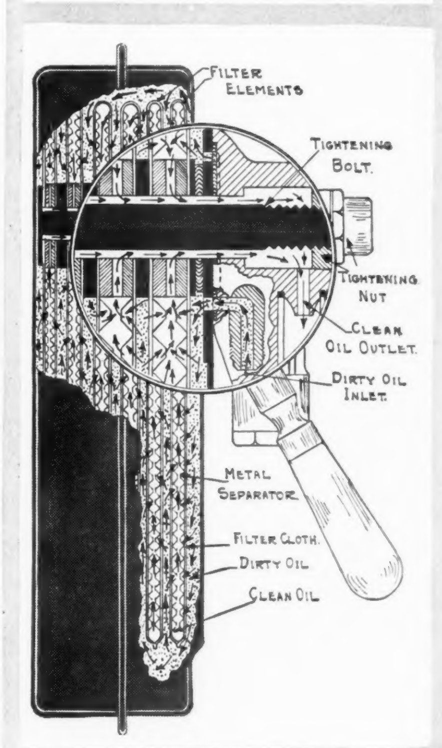
Courtesy of Motor Improvements, Inc.

Fig. 5—Location of an oil filter adjacent to the engine of a motor bus. Note accessibility and compactness of installation.



Courtesy of Rectifier Mfg. Co.

Fig. 6—Details of an oil filter of comparatively high filtering area.



Courtesy of Motor Improvements, Inc.

Fig. 7—Details of the Pur-Olator oil filter. This device involves filter cloth elements through which crankcase oil can be by-passed.

Courtesy of A C Spark Plug Co.

Fig. 8—Another type of crankcase oil filter. Dirty oil enters filter under pressure at 1; is forced into tubular passages of filter bag 2; dirt is left on inside of this bag. 3, indicates clean oil passing through a cylindrical supporting screen for the filter bag. At 4 clean oil enters tank, to return to crankcase at 5.

Typical Equipment for Purification of Motor Oils

As a result the motorist can, after all, get some benefit out of a discussion of these characteristics, though of course, only from a relative point of view. So for his information, an understandable definition follows, with a description of the customary method of test, viz.:

Actual Meaning of Terms "Flash" and "Fire"

When the temperature of a petroleum product is gradually raised, a point will be reached where enough surface vapor is developed to ignite for a moment upon the application of a flame. The temperature of the oil at the moment of flash is regarded as the flash point of the product under test.

This test for flash point is arbitrary in that it depends upon the type of apparatus used, i.e., whether this latter employs an open or closed cup. In the United States the open cup prevails, the closed cup device being more largely confined to foreign usage.

Continue Raising Temperature for Fire Point

After having raised the temperature of the lubricant to the flash point temperature, heating can be continued in the same gradual manner until actual ignition takes place when the test flame is applied. When ignition continues for a period of at least 5 seconds the temperature of the oil at the time should be noted as the fire point.

Freedom From Draft Essential

Both flash and fire point tests should be made in a room or compartment which is free from air drafts. In fact, the observer should even avoid breathing directly over the apparatus inasmuch as this might materially affect ignition of the vapors. To make the flash more readily discernible, the room should be darkened whenever possible.

Value as a Guide to Lubrication Ability

As a guide to the lubricating ability of any oil, flash and fire point readings are of value only as indicators of the relative initial volatility. They should not be regarded as definite temperatures at which boiling takes place, or at which the products may pass completely over to the vapor stage.

The extent to which vaporization of a motor oil may occur at temperatures below its apparent flash point will largely depend upon the proportion of low flash point or high volatility hydro-carbons which may constitute its make-up. This may be a very important factor with certain types of oil for it will lead to abnormal consumption of oil and a false impression as to the actual cause.

Relation to Viscosity

Higher flash and fire point oils will in general be of higher viscosity if of similar composition from a hydro-carbon viewpoint. This, however, lines up with the general requirements of high temperature lubrication as brought out in the discussion of viscosity.

CRANKCASE DILUTION

Crankcase dilution has been given extensive attention by automotive authorities, both in the research laboratory as well as in technical discussions. To the motorist, however, dilution will frequently be a vague term for something that he may have been told will have a varying effect upon his engine. The relation of dilution to carbon formation has already been mentioned. It is fitting now to discuss this matter as a whole, with special reference to the possible effects during warm weather driving.

What It Means

Practically speaking, crankcase dilution means reduction in the body or viscosity of motor oils due to condensation or deposition of a certain amount of unburned gasoline on the cylinder walls. Some of this will eventually reach the crankcase due to the continued interchange of freshly sprayed oil with the oil film on the cylinder walls.

Detriments Reduced by Modern Engine Design

Improvements in the design of the modern automotive engine have reduced the detrimental effects that dilution may have on engine lubrication. For dilution is influenced by engine and crankcase temperatures. In other words, the temperature of the cylinders must be sufficiently high to insure complete vaporization and burning of the gasoline. Otherwise more or less of the heavy ends or fractions of low volatility will remain unvaporized. But of course such temperatures should never be too high.

Requirements for Effective Combustion of Fuel

To burn gasoline effectively in the automotive engine requires atomization and mixture with a certain amount of air. To attain efficient vaporization this mixture of fuel and air must be heated in order to insure the best results.

The direct consequence of exceedingly rich mixtures under too low engine temperatures will be dilution of the lubricating oil in the crankcase. Of course, when the engine is operated under average conditions of atmospheric temperature or after it has come up to its own normal temperature of operation there will be little or no difficulty experienced in vaporizing

the average grades of gasoline. Under relatively cold engine conditions, however, the amount of gasoline which will be vaporized will normally be decidedly lower. There are two ways by which this difficulty can be overcome to a certain extent, i.e.:

1. By the use of gasoline of relatively higher volatility.
2. By "priming" or "choking" of the carburetor.

Meaning of These Terms

Priming is the addition of an extra amount of gasoline to the cylinders through pet cocks or a priming pump. Choking constitutes the manipulation of the carburetor in order to increase the richness of the mixture, or obtain approximately the requisite percentage of fuel **in the form of gas** by reducing the amount of air delivered to the carburetor on starting. Carburetors are normally adjusted when hot in order to obtain good fuel economy, and to decrease dilution; hence, a certain amount of control by means of the choke is made necessary in order to meet cold starting conditions.

Effect on Dilution

Priming or choking, however, while they facilitate starting a cold engine are also conducive to increased dilution inasmuch as under such conditions less of the gasoline will vaporize than when operating under normal temperatures. As a result, considerably more of the higher boiling point fractions will remain in liquid state, to leak past the piston rings and either wash the film of lubricating oil from the cylinder walls or become so incorporated with this film that reduction in viscosity will occur.

The ultimate result of either of these occurrences will be dilution due to entry of the fuel into the oil film on the walls, or into the crankcase.

Due to the fact that the cylinder walls will always be insufficiently lubricated after the use of the choke, the engine should be operated at moderate speeds for a few minutes, until the film of lubricant is renewed on all surfaces where any washing action has taken place.

Dilution More Prevalent in Cold Weather

It is evident that during cold weather operation with average fuels we may expect more dilution due to the presence of unvaporized fractions of the fuel in the system.

The use of more volatile gasoline, of course, would obviate this condition to a certain extent. The fact must not be overlooked, however, that dilution will occur with any motor fuel even where so called high test aviation gasolines are used. The higher the volatility, however, the less will be the necessity for using the choke in cold weather operation.

Care Necessary in Priming or Choking

Both priming and choking must be carefully carried out. Especially in the use of the choke will there be the possibility of considerable dilution occurring. If used excessively for any length of time naturally a comparatively uniform flow of very rich mixture will occur. The correct way is to alternately work the choke slowly back and forth until sufficient explosions have taken place to insure continued operation. It should then be pushed in gradually and the engine idled until sufficiently warmed up.

During the process of warming up it is well to adjust the spark and throttle levers as nearly as possible to a point where the engine will run evenly and fire on all cylinders. Where cars are equipped with a primer, in very cold weather the priming charge should be shot into the manifold while turning the engine over with the starter. This will insure getting the charge into the compression chamber.

Importance of Volatility

The question of using more volatile grades of gasoline so frequently arises that it is well to discuss the subject briefly.

Today gasolines contain considerably more of the lower volatility hydrocarbon fractions than formerly, due primarily to the ability of the petroleum industry to meet demands by improved methods of manufacture.

Gasolines produced under some modern refinery processes have a lower final boiling point than those which were formerly manufactured. As a result they are capable of developing more power.

Effect of Engine Design

Dilution will also vary to a certain extent with the design and mechanical condition of the engine, as well as with the volatility of the fuel. Where an engine is designed especially to burn a certain grade of the latter the possibility of dilution occurring will be decreased.

This is also true where provision is made to keep the crankcase oil temperatures relatively high. But little has been done in the way of installing provisions for heating the lubricating oil in the crankcase of the average car today.

In practically every other way, however, effort has been made to design engines so that the least amount of dilution will occur. The increased temperature of operation in the event of heavy service will decrease the rate of dilution to a certain extent by virtue of the fact that the so-called heavy ends of the fuel will be more completely vaporized and burned, and not absorbed to as great an extent by the lubricating film on the cylinder walls.

Rate at Which Dilution Occurs

It is decidedly interesting to note the accompanying curve, which shows the rapid drop in viscosity, due to dilution. As can be seen it does not require very much diluent mixed with the motor oil to reduce the viscosity or thin down the oil sufficiently to perhaps render it less effective as a compression seal. It has often been determined that dilution occurs very rapidly over the first few hours of operation after the lubricant has been renewed in the crankcase.

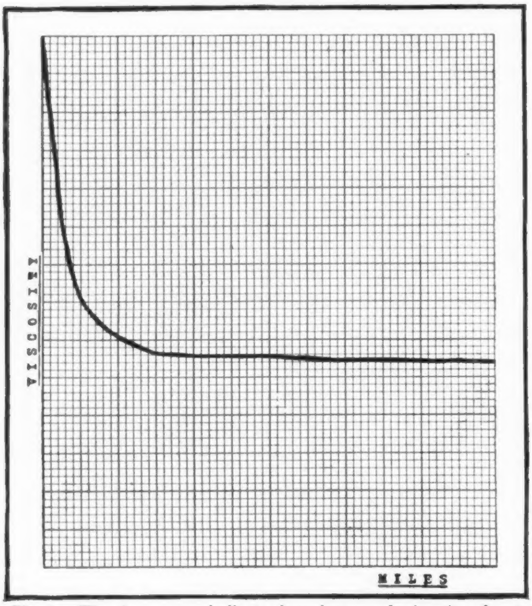


Fig. 9.—The above curve indicates how, in general, viscosity of motor oils decreases with mileage. Definite figures as to how rapidly viscosity reduction will take place (owing to dilution) or as to just what the ultimate viscosity will be, will vary in different instances. It has also been found that the curve will be relatively smooth in some cases while in others it will be undulated to a certain extent. The exact form of such a curve will depend upon the make of the car, its age, the efficiency of the engine, the amount of make-up oil added, and more particularly upon the ability of the driver to handle his car properly.

There has been an extensive discussion as to just how important this matter of dilution really is and just what harmful effects may result from its occurrence. The dangers therefrom have, of course, been exaggerated, as is always the case. Up to this time any efforts which have been made to overcome dilution have provided for elimination after occurrence. Usually these have involved heating of the oil. This is not really desirable as it inevitably gives rise to oxidation. Where oil dilution exists it is logical to expect that more power will be developed at the crank shaft, due to the decrease in internal friction in the lubricant, provided it is not diluted to such an extent as to allow metal-to-metal contact.

Effect of Foreign Matter

The presence of water, sludge, emulsion, grit and dirt all tend quite as much to promote inefficient lubrication. In fact an excess of sludge, which might clog oil ducts or render the pump inoperative would certainly cause more direct damage than a mere reduction in viscosity of the lubricant.

Effect of Throttling

Dilution, of course, may also vary with the extent of throttling. Under certain carburetor conditions, with low throttle operation dilution may be greater than under higher power operation. Of course, the matter of vaporization enters into the question especially in regard to the theory concerning the occurrence of dilution by fuel deposition from the vapor state.

Bearings Rarely Damaged by Dilution Alone

It will appear that from a lubricating point of view there is little probability of bearings being actually burned out, because the viscosity of the lubricant has been reduced to the extent that it would be under average cases of crankcase dilution.

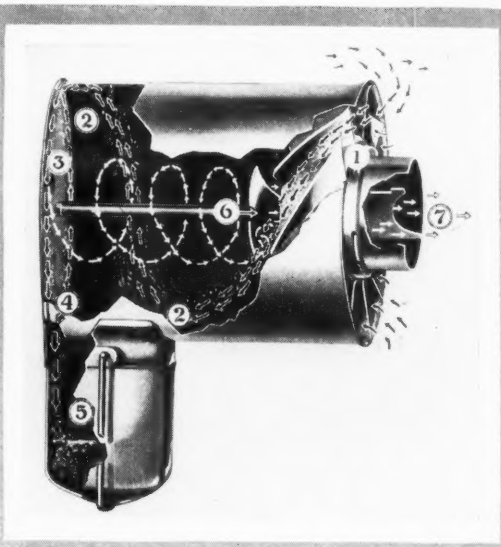
Any number of instances are on record where motor trucks have experienced dilution to the extent that their crankcase oil was decreased to less than one-fifth the original viscosity. Yet they operated effectively and on examination their engine bearings showed no ill effects. When trouble is experienced it will usually be due to abnormal operating conditions.

From a bearing viewpoint it will be of interest to note, however, that reduction in viscosity due to dilution will tend to promote the pumping of oil by journals in their rotation, inasmuch as lighter fluids will lend themselves to more ready handling, if it can be called such, but only under lower speeds. The higher the rubbing speeds the lower will be the pumping efficiency of the bearing.

But Oil Must Be Carefully Refined

Furthermore, increase in the rubbing speed of a journal and bearing causes an increase in frictional heat. As a result a diluted engine oil, under higher speeds and normal operating temperatures must possess very high lubricating ability and be as free as possible from carbon or other foreign matter if it is to furnish a suitable film to protect the bearings. **Only can this be obtained by the most careful refinement, and the rendering of the original oil as pure as possible.**

Unless the oil has been given every attention in its refinement there will be considerable possibility of it being broken down in service especially where the frictional heat developed in the bearing is not being adequately carried away by the oil itself.

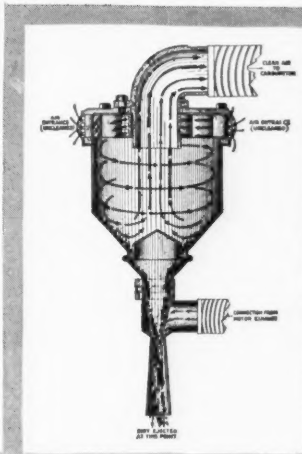


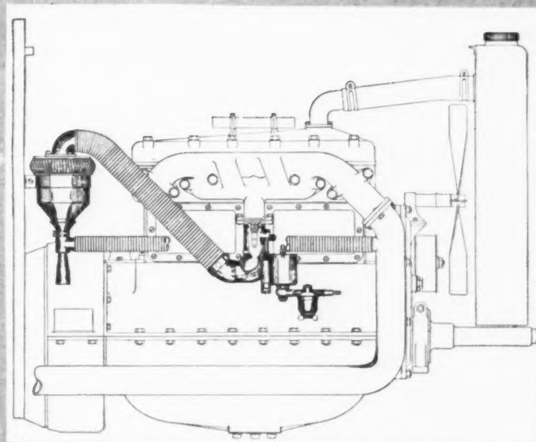
Courtesy of A C Spark Plug Co.

Fig. 10—An air cleaner employing centrifugal force. At 1 suction stroke of motor draws in dust laden air. 2: Centrifugal force separates out dust particles. 3: Spiral movement of dust carries it to rear, where it is ejected at 4, to collect in removable container 5, Clean air 6, as indicated by arrows passes through cleaner in a helical path, is straightened and goes to carburetor at 7.

Courtesy of Stromberg Motor Devices Co.

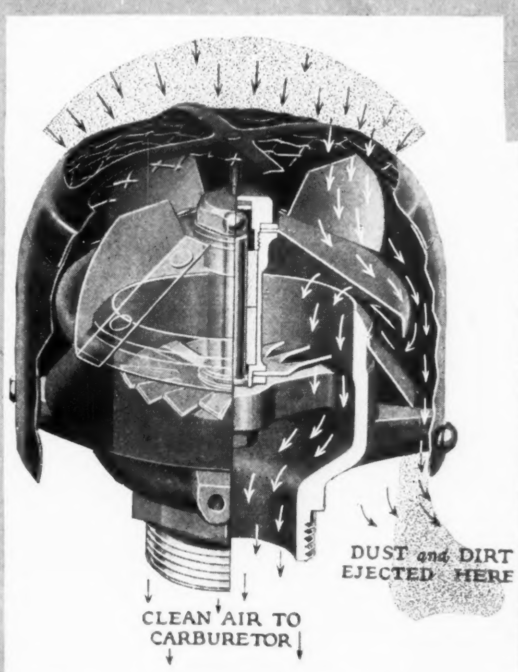
Fig. 11 — Another centrifugal type of air cleaner with upward path of air indicated by arrows. Dust and dirt passes downward as shown.





Courtesy of Stromberg Motor Devices Co.

Fig. 12—Method of installing a centrifugal type of air cleaner on an engine.

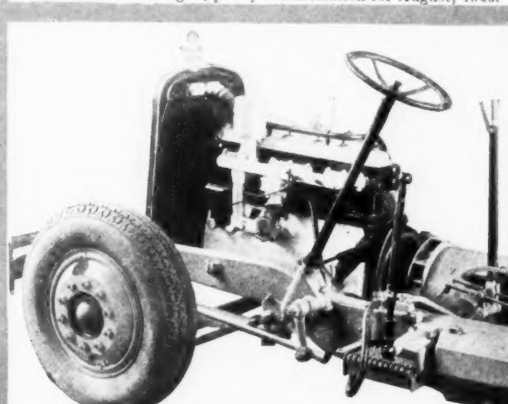


Courtesy of United Manufacturing and Distributing Co.

Fig. 13—Details of an air filter which uses a combination of centrifugal and centripetal force to eject dust and dirt from the air entering the carburetor.

Courtesy of Staynew Filter Corp.

Fig. 14—A motor bus engine equipped with air filters which use felt fabric for removal or filtering of the dust. This type of air filter is shown in detail in Fig. 5, p. 92, of Lubrication for August, 1926.



Typical Equipment for Cleaning Air Prior to Passage Through the Engine

The ideal in automotive bearing construction is to plan for practically the entire removal of frictional heat by the oil, thereby preventing this heat from reaching either the bearing surface or journal. But this ideal is not practically obtainable. Therefore the oil must be of such a character as to:

1. Be capable of maintaining the requisite lubricating film.
2. Resist the breaking down effects of heat as far as practicable.
3. And develop as little hard carbon as possible if subjected to continued service under overheated conditions.

Effect of Carbon on Bearing Lubrication

Carbon in an engine combustion chamber, on valves, piston heads, on spark plugs or in ring grooves, etc., is a detriment from the viewpoint of ultimate power developed as has already been mentioned.

In bearing clearance spaces, however, it may in addition result in mechanical failures due to an impairment of circulation of the lubricant by the clogging of grooves or oil ducts. It must, therefore, be guarded against with the utmost care.

Oxidation Also a Factor

Another interesting and extremely important point involving carbon is that in the free state it has an apparent tendency to promote or aid oxidation just as does other foreign matter such as particles of brass, copper, iron, or dust and dirt.

Of course, oxidation of lubricating oil is not as serious a matter in an automotive engine as in the steam turbine. On the other hand it is the forerunner of emulsification and the development of insoluble sludge, especially where the oil is agitated in heated condition with any water which may have gained entry into the crankcase.

According to certain authorities if emulsification is prevented, the tendency towards sludging will be greatly decreased, assuming, of course, that a certain amount of water must always be contended with in practically every crankcase.

It would therefore seem logical to attempt to eliminate the so-called foreign matter catalyzers including free carbon, as mentioned above, which promote oxidation and ultimately give rise to sludging.

Emulsification is certainly not as detrimental as sludging, nor are emulsions alone as objectionable as insoluble sludges which may tend to clog oil passages, congest the lubricating system and generally reduce the ability of the oil to give continued and effective lubrication.

In any event oils, whatever their purity, will be subjected to more or less oxidation where agitated under continued high temperatures and in the presence of air. However, the more highly refined the oil, or in other words, the greater its purity, the more remote will be the possibility of oxidation occurring to an abnormal extent.

In brief, research indicates that there are certain component hydro-carbon fractions which oxidize more readily than others. These can be removed in the process of refining, as experimentation and practice have demonstrated, to the evident improvement of the resultant lubricating oil, viz.: the color for example.

Color a Valuable Indication

Color is a decided indication of the purity of an oil, and other things being equal with oils of a similar nature the clearer, lighter products are better adapted to the exacting conditions which exist in the average automotive engine. Color is usually an indication of the degree of refining and hence the lighter the color in oils of a similar nature, the less will be the tendency to form tars and carbon.

Printed in U. S. A. by
Edgar C. Ruwe Co., Inc
72 Washington St., N. Y. C